KNOWLEDGE AND UNDERSTANDING OF THE OCEANS PROMISE TO ASSUME GREATER AND GREATER IMPORTANCE IN THE FUTURE. THIS IS NOT A ONE-YEAR PROGRAM–OR EVEN A TEN-YEAR PROGRAM. IT IS THE FIRST STEP IN A CONTINUING EFFORT TO ACQUIRE AND APPLY THE INFORMATION ABOUT A PART OF OUR WORLD THAT WILL ULTIMATELY DETERMINE CONDITIONS OF LIFE IN THE REST OF THE WORLD. THE OPPORTUNITIES ARE THERE. A VIGOROUS PROGRAM WILL CAPTURE THOSE OPPORTUNITIES. SINCERELY, JOHN F. KENNEDY. – *Letter to the President of the Senate on Increasing the National Effort in Oceanography* **March 29, 1961.** ***http://www.presidency.ucsb.edu/site/docs/pppus.php?admin=035&year=1961&id=100***


Photo from Paula Keener-Chavis (NOAA)

The words of President Kennedy are, perhaps, more important now than they were in 1961. Caught up in the race to put a man on the moon, the United States put ocean research and exploration on the back burner. The Ocean Observatories Initiative (OOI) is, after over forty years, bringing the ocean back into national prominence. As part of this effort, it is imperative that ocean science researchers (and their institutions) become proactive in searching out and setting up relationships with both informal and formal education organizations (K-20). Outreach is one of the two criteria for National Science Foundation proposals and similar criteria are being used by other funding agencies. The integration of research and education is one of "three core strategies that guide [NSF] in establishing priorities, identifying opportunities, and designing new programs and activities.... Effective integration of research and education at all levels infuses learning with the excitement of discovery and assures that the findings and methods of research are quickly and effectively communicated in a broader context and to a larger audience" (NSF GPRA Strategic Plan 2001 - 2006) [http://www.nsf.gov/pubs/2003/nsf032/bicexamples.pdf].

This white paper will address the issues associated with researchers working with the informal education community. The first part of this paper will address the definition of the informal education community and the reasons why they are so important to include in the ORION effort. The second part of the paper will focus on some of the potential interactions and the pros and cons associated with these interactions. Finally, some ideas about how ORION and the informal education community might interact will be presented for consideration. This paper is not meant to be all-inclusive, but hopefully will provide a solid starting point for our conversations and discussions in Puerto Rico during the ORION meeting in January 2004.

Part I. What is Informal Education and who are Informal Educators?

In the United States there are ~78.3 million people either providing or pursuing formal education (http://nces.ed.gov/pubs2003/digest02/introduction.asp) and there have been many efforts to integrate scientific research into the formal education community. It is important to increase this effort to include informal education as well. Informal education is a process that can take place anywhere and anytime and it has the potential to reach all ~288 million people in the nation. The recent NSF COSEE initiative (http://www.cosee.net/) required that each COSEE Center include an ocean science research institution, an informal education organization, and a formal education component. For NSF, informal science education includes almost all the experiences outside of the formal classroom setting. These include television programs, films, radio shows, exhibits and educational programs of museums, science and technology centers, aquaria, nature centers, zoos, libraries, as well as community and youth-based programs.

As part of Capitol Hill Oceans Week 2002, Valerie Chase presented a paper titled "**Ocean Science Education from Museums, Zoos, Aquariums and Science Centers"** in which she provided an excellent overview of informal education (http://www.nmsfocean.org/chow/chase.pdf) and why these institutions are a valuable addition to an outreach/education effort**.**

> *The best way to think of informal education is as free -choice learning: learning in which the individual selects from a very carefully constructed exhibit, program, IMAX, video, book or Internet program what he or she chooses without the intercession of a "teacher". To the uniformed "informal" implies unstructured or disorganized. Nothing could be farther from the truth. Informal educators implement a large body of research on free-choice learning as well as formal education research. We base our programs and materials on cutting edge ocean science research – often from first person interaction with ocean scientists rather than waiting for primary literature to be published. We test the programs and materials we produce, doing evaluation of learning in the populations we seek to educate. Our evaluations are formative - to insure that we are communicating effectively, and summative – to prove to our funding sources that we have achieved the goals and objectives set forth in our grant proposals. We publish our evaluation results in peer-reviewed literature so that others may learn from our efforts.*

Dr. Chase included zoos, aquariums, museums, and science centers because of the incredible attendance numbers. There are over 110 million visitors each year to zoos and aquariums in the United States (http://www.aza.org/ForEveryone/). There are ~16,000 museums in the United States and they receive more than 850 million visits per year, more than all the country's professional baseball, football, and basketball sporting events combined (http://www.aam-us.org/public.cfm?menu_type=museums). A 2002 survey from the Institute of Museum and Library Services (IMLS) indicates that museums spend over a billion dollars annually and contribute over 18 million instructional hours per year on programs that support every academic discipline for K-12 schoolchildren (http://www.imls.gov/pubs/pdf/m-ssurvey.pdf). The NSF report *Science and Engineering Indicators 2002* (http://www.nsf.gov/sbe/srs/seind02/c7/c7s4.htm) shows that 66% of the 1,574 adults surveyed had visited a museum or technology center in 2001. These organizations reach a large portion of the population and have invested a tremendous amount of money toward bringing their messages and content to the public. Yet researchers have been content to publish their findings in peer-reviewed publications that do not reach the general public or most K-16 classrooms.

Informal educators have an enormous wealth of experience that can be turned toward making ocean education engaging and inspiring and by inspiring, they help citizens to care. *Science and Engineering Indicators 2002* also states "the Internet ranks a distant third as Americans' chief source of news in general" but it is, however, the preferred resource for information about specific science topics. This means that it is crucial for ORION to utilize other modes of outreach in addition to the Internet if we want the public to learn about observatories in general as well as specific topics.

Part II. Why work together?

> ***SYNERGY****: Etymology: New Latin* synergia*, from Greek* synergos *working together.* ***1:*** *Synergism: broadly; combined action or operation.* ***2:*** *a mutually advantageous conjunction or compatibility of distinct business participants or elements (as resources or efforts).*

There are many benefits from collaborations that are particularly useful in today's economy and rapidly developing science and education fields. The scientists and engineers have the expertise and experience with the research and data interpretation. Informal educators have the expertise, experience, and time (with adequate funding) to turn current research and findings into useful, desirable educational tools. This type of collaboration merges the best of two worlds and means that practitioners in each field do not need to learn a completely new set of tools and vocabulary.

There are also many barriers to developing and forming these collaborations and it is important to not only see the finish line but also the hurdles that have to be overcome on the way. These hurdles include differences in education levels, salaries, cultural background, objectives, goals, and methodologies. None of these are insurmountable but they need to be recognized and addressed. For example, on the salary gap hurdle, this becomes vividly apparent on research proposals when researchers ask for summer salaries (often between $5,000-$8,000/month) and then expect teachers to work for a $100-$1000 stipend for the summer. Researchers need to realize that most educators are poorly paid and often are also on a 9-10 month salary scheme and need a competitive summer salary. Education and research collaborators should understand each other's reasons for forming the partnership. Some researchers view educational outreach as a necessary evil, required by funding agencies. Educators value the opportunity to access scientific expertise, research experiences, and data, but some object to participating as a token component of a project. Researchers may discover that outreach may bring recognition for their work that scientific publications cannot provide.

Discussions of content are common during collaborations. Scientists often push for a high level of content in the scientific jargon of their field while educators may rephrase in more familiar language and moderate amount of content. This cultural gap is evident in the different standards for communication: scientists by means of lectures and scientific publications, and educators by visual displays and words that simplify concepts for the general public. For example, graphics for a museum exhibit with limited wall space may use a short caption in large font to capture attention rather than more content in smaller font that scientists would prefer. Scientists should acknowledge and respect human learning theory and research, just as the educators need to understand that it is difficult for researchers to trim or rephrase content. Perhaps our discussions in Puerto Rico can begin to list some of these hurdles as well as some techniques useful in overcoming them.

To create a successful and productive partnership, it is essential that there is a mutual recognition of the importance of working together in a spirit of creativity, openness, and trust. While the expectations of every organization will vary with internal priorities and missions, it is necessary to understand the priorities and to respect the partnership. Providing staff who are responsible for the collaboration and have the authority to allocate resources is crucial for success. Nothing will hinder collaboration more than having members who have to constantly go back to their institutions for decisions.

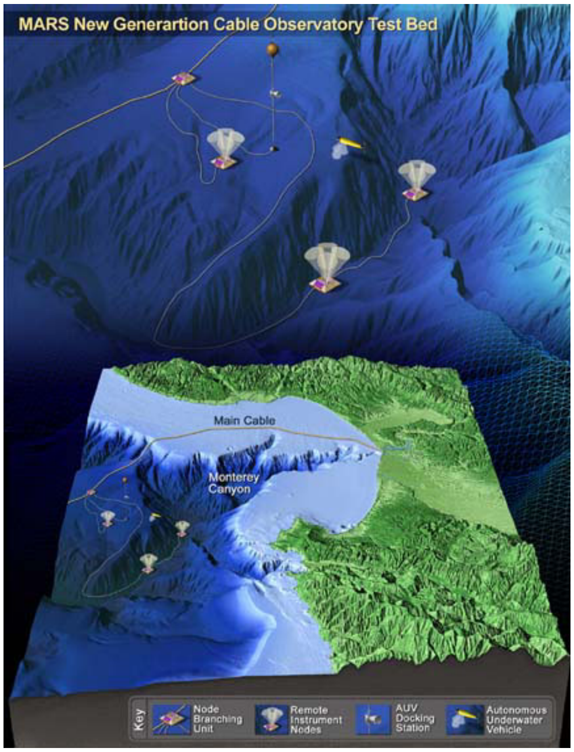
Collaboration benefits to the informal educators include (but are not limited to):

- The expertise of scientists, engineers, and experts in various fields who provide accurate and timely information.
- Access to cutting-edge technology and scientific research which can be interpreted to the public. The public is interested in real science and data, not that it needs or wants real-time data, but, as with many other disciplines, learning with real examples is exciting, intriguing, and memorable.
- High quality, unique illustrations, photographs, and video images to enhance exhibits, publications, and educational products. The often-used adage that "a picture tells a thousand words" might seem trite, but it is very true, and access to the types of imagery that researchers often collect is invaluable.
- The use of research equipment and technologies to support the goals and mission of the informal educators. Researchers have access to tools, equipment, and technology that many informal educators just dream about (if they've even heard about them). So, providing access to this type of equipment or even just the results gathered with the technology is very useful to educators.

Similarly, from the research institution's perspective, the benefits of collaboration include access to unique opportunities and the valuable skills of the informal education staff, including (but not limited to):

- Support to the research institution in effective dissemination of information to the media and the public. Although some research organizations have a communications group or PR firm, most rely on the occasional conversation with a journalist or giving public lectures. Informal education staff who have developed effective techniques and strong working relationships with the media enhance the dissemination of information.
- Expertise in the areas of education, communication, and assessment. With the new education criteria present in most funding agencies, it is more important than ever that researchers provide effective outreach. Just as one wouldn't expect to write and develop a research component outside of one's field, one shouldn't try to write and develop an educational outreach plan without consulting with experts in the field. Collaborations can provide that access and may even liberate the researcher from having to write that section of the research grant. Researchers should expect that ~10% of the total budget should be allocated to educational outreach and assessment.
- Provision of a competent and cost-effective conduit for the research institute's educational message. There should be at least one person on staff whose specific job duties include education and outreach and this person should be senior enough to be empowered with decision-making ability and the ability to allocate resources. If this person works on collaborations with informal education groups, then they can tap into resources at a very reasonable cost compared to the cost of trying to maintain a separate education staff.
- Collaboration with informal educators (as well as graphic artists, exhibit designers, writers, and other professional communicators) provides the science experts an opportunity to see how to effectively communicate messages with a minimum of words.

Part III. Potential Collaborations/Programs focusing on Ocean Observatories



This proposed project of the National Science Foundation will enable the US to establish a permanent presence in the oceans. This will be accomplished using a variety of technologies and instruments on multiple time and spatial scales. The current plan is to develop sampling programs at the regional, coastal, and global scale.

The purpose of this meeting is to determine the initial science plan for ORION. At the same time, researchers and educators have an unparalleled opportunity to guide ocean education and outreach into directions and depths never before reached. With power and data flowing in both directions, we have the ability to gather immense amounts of data in real time. There are a large number of additional collaborations that also are worth discussing to learn from their successes and difficulties. Three of these will be discussed here with additional ones listed at the end of this document (Appendix I).

One program that is currently underway is a collaboration between the Monterey Bay Aquarium Research Institute (MBARI) and the Monterey Bay Aquarium (MBA) as well as partners like Rutgers University (COOL Classroom) and the Virginia Institute of Marine Sciences (the BRIDGE web site). This MBARI/MBA collaboration allows us to test new ideas for public outreach and education. **Education and Research: Testing Hypotheses (EARTH)** is a program that will set the groundwork for providing teachers with the means to interactively integrate near-real-time data with existing educational standards and tested curriculum (http://www.mbari.org/education/EARTH). This program draws on the strengths of both institutions, enabling a product that would have been costly and not as useful if we had tried to do this independently. MBARI will provide the scientific content and the relevance of the data being collected while MBA will provide guidance and support for running and evaluating teacher training institutes and developing curricula. A more complete discussion of the collaboration between MBARI and MBA has been published in EOS (Matsumoto and Kochevar, 2003. EOS 84(26):241-246).

Developing written materials for adoption for formal education is extremely difficult as the adoption standards for each state vary and it takes a long time for a product to become 'approved'. In California and other states, educators cannot spend state funds on materials that are not approved [http://www.k12alliance.net/science_materials.html]. A collaboration was formed between Woods Hole Oceanographic Institution (WHOI) and Turnstone Publishing (with a national publisher Steck-Vaughn, a subsidiary of Harcourt General). This collaboration illustrated some of the difficulties of making formal education ocean science materials available in a national market focused on quick turnover. The partnership was supported by WHOI and produced 8 ocean science books with teacher guides for grades 4-8 that are aligned with National Science Standards. These books are wonderfully written [http://www.whoi.edu/home/education/k12_turnstone.html] but the books did not sell as expected. Turnstone Publishing Group also partnered with Steck-Vaughn on books with the Smithsonian Tropical Research Institute and the Harvard Center for Astrophysics, but has since ceased to exist.

The COMPASS (Communication Partnership for Science and the Sea) mission is to help marine conservation science become a discipline that is more cohesive, better communicated and better connected to and informed by policy (http://www.compassonline.org). ORION could emulate this type of collaboration with a focus on observatory research, education, and policy.

There are a number of potential projects that are listed here in order to elicit discussion. While the discussion for each specifies informal education, the capabilities are easily transferable to formal education.

- Development of camera system/AUV/ROV for deployment (plug and play) on any of the observatory platforms. This system would have educational projects as a priority. Control of the camera/AUV/ROV could be over the Internet either directly by the public (at informal education institutions) or indirectly, via informal educators.
- One potential project would be to develop control software for the ROV or an AUV based on LabView. The rationale for this is that it could possibly link to a classroom program working with LEGO ROVs and RoboLab software (which is based on LabView). Here, students who build a LEGO ROV can program specific missions designed to test their hypotheses. Once these missions are successful in the classroom, they can export the program to the real ROV on the observatory network and have their mission carried out (and view the results over the internet).
- Access to standard physiochemical data gathered by the observatory network can be used for exhibit development focused on weather, climate change, physical oceanography or a wide variety of other topics. Most of these subjects are not well covered by informal education institutions.
- The imagery that might be gathered by the observatory network has immense potential for informal education. Still images and video have the ability to capture the attention and imagination of all.
- Communicating science to the general public via the popular press, news agencies, and/or specialty broadcasts (e.g. Discovery, National Geographic) has to be an important component of the ORION educational outreach plan. Dissemination in this manner has the potential to reach millions, many of whom would not have access to the information from formal educators and may not visit informal education institutions. For example, the recent BBC Abyss Live (http://www.bbc.co.uk/nature/programmes/tv/abysslive/) program reached ~6.6 million people in the United Kingdom.

The examples provided here give an indication of potential power of this type of relationship and will provide a good starting place for discussion at the ORION workshop. While many have been 'converted' to integrating educational outreach into our research activities, there are many colleagues who have not yet seen the light. During her entire, and altogether too short, career, Dottie Stout helped lead the way with regard to ocean science education. Let's keep the drums beating!

> ***"IT HAS BEEN MY OWN PERSONAL PASSION TO BEAT THE DRUM TO ENCOURAGE MORE SCIENTISTS TO BECOME AWARE OF THEIR OBLIGATION AND RESPONSIBILITY IN EDUCATION AT MULTIPLE LEVELS. THIS DOES NOT MEAN THAT RESEARCHERS MUST BECOME EXPERT EDUCATORS. BUT IT DOES MEAN FOSTERING COLLABORATIONS BETWEEN RESEARCHERS AND EDUCATORS IN ORDER TO GET THE POINT ACROSS. THESE RELATIONSHIPS ARE NOT JUST INCREDIBLY REWARDING, THEY ARE INTEGRAL." – DR. DOROTHY L. STOUT, 2001.***

APPENDIX I.

There are some additional collaborations that are listed here to serve as additional discussion points for our meeting. These do not represent all of the programs that exist but represent some of the programs that signed up for the real-time data sessions at the upcoming ASLO/TOS 2004 Ocean Research Conference in Hawaii (February 2004). Just the programs that include collaborations with informal educators are listed here, there are others that represent research institution efforts that are also noteworthy. All of them feature real data and should be evaluated for their potential applicability to ORION.

- *Experience using the Bermuda Atlantic Time Series (BATS) in education.* A collaboration between the Bermuda Biological Station for Research, Florida International University, and the College of Exploration providing ocean data in an Excel spreadsheet format (http://www.coexploration.org/bbsr/classroombats).
- *Using OPeNDAP and Live Access Server to bring real-time data to the classroom: lessons learned in teacher workshops*. NOAA National Marine Sanctuary Program and the National Oceanographic Data Center are integrating real-time and retrospective data sets and testing new access portals (http://ferret.wrc.noaa.gov/Ferret/LAS/LAS_servers.html#NOAA).
- *Using data in the classroom–what can teachers use?* National Geographic Society, NOAA National Marine Sanctuary Program and the Office of Exploration have partnered in a 9 month virtual teacher conference bringing key ocean concepts to teachers. (http://coexploration.org)
- *Using real-time environmental data for education.* The Center for Improved Engineering and Science Education (CIESE) is working with educators to use technology to engage students in learning (http://k12science.ati.stevens-tech.edu/).
- *Eyes on the Bay brings Maryland's Chesapeake and coastal bays to the classroom*. NOAA brings real-time monitoring data (water quality) to the classroom along with lesson plans and other links (http://www.eyesonthebay.net).
- *Connecting the NOAA National Marine Sanctuaries to classrooms through telepresence.* NOAA's National Marine Sanctuary Program is developing (in partnership with the Jason Foundation for Education and the Institute for Exploration) a virtual telepresence initiative (http://www.usatoday.com/news/science/2001-06-26-shipwrecks-usat.htm).
- *In-class acquisition of real-time AVHRR satellite data directly from polar-orbiting space platforms: an inexpensive and multidisciplinary educational approach*. The University of Hawaii and NOAA CoastWatch is putting inexpensive AVHRR-APT receiving stations into schools and setting up an Internet portal (http://coastwatch.nmfs.hawaii.edu/).
- *Real-time monitoring of chromophoric dissolved organic matter (CDOM) and water quality in the Neponset River: use in local middle school classrooms*. A real-time data stream on the web developed by the Watershed Integrated Sciences Partnership (WISP) and the New England Regional Center for Ocean Science Education Excellence (http://www.wisp.umb.edu/).
- *Bringing real-time ocean science data into the classroom through coastal ocean observatories and the mid-Atlantic Center for Ocean Sciences Education Excellence*. The MA-COSEE is working with Rutgers University Coastal Ocean Observation Lab (C.O.O.L.), the New Jersey Shelf Observing system (NJSOS) and CIESE to bring real data into the classroom (http://www.macosee.net/).
- *A model for an international real-time ocean observatory for high school studies*. This collaboration between University of Miami and SeaKeepers Org. will utilize SeaKeeper modules on a variety of ocean platforms and send the data back to the high schools in real time (http://www.seakeepers.org/technology/rnd.htm).